GPS Tracking System for Low Maintenance Application

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***Abstract* – A GPS tracking system utilizing the license-free RF communication is proposed as viable alternative to using the available GSM network for low-cost maintenance. The proposed system is designed based on the popular 8-bit embedded system. It consists of a monitoring unit and a remote unit. Each unit is equipped with, among others, a GPS receiver and an RF transceiver as main components. While there is a need for the remote unit to be small and compact, the monitoring unit is also designed as a portable device. Prototypes are built for design verification. Initial functionality test shows that the system is capable of tracking mobile object not only in outdoor but also in indoor environment.**

***Keywords*:** GPS, RF, microcontroller, embedded system

I. INTRODUCTION

The maturity of GPS (Global Positioning System) technology has led to its increasing utilization in commercial applications. Popularly used as navigational aid, GPS technology has, in recent years, made a tremendous in-road as a reliable tracking system for mobile objects. Combined with mobile communication network such as GSM network, it evolves into GPS tracker that capable of tracking mobile objects in real-time. Acting like a beacon, GPS tracker transmits positional information to a monitoring station at regular prescribe intervals allowing instant analysis of data transmitted. GPS tracker has been successfully deployed in business environment where there is a need to monitor large mobile workforces and assets such as commercial fleets, logistics and transportation companies. Tracking ability of such system is only limited to the availability of GSM network coverage [1].

One drawback of this GSM-GPS tracking system is the need to maintain monthly subscriptions for mobile network. Despite the fierce competition amongst network providers resulting in the falling subscription fees, the additional maintenance cost has made it not very attractive for industries such as ports, container terminals, large construction sites golf courses and open-pit mining where their mobile assets are deployed over prescribe perimeter. For these industries, a GPS tracking system utilizing license-free RF wireless communication is proposed. As a viable alternative to GSM network, RF channels allow for free data communication up to a distance of 10km radius from base station.

This paper discusses the design of a RF-GPS tracking system known as Smart Wireless Tracking System (SWiTS). The system is designed and developed based on a popular 8-bit embedded system [2]. The paper begins with an overview on the architecture of the system and its major components that constitutes the system. It proceeds with the description of the algorithm for the tracking system. Results of the several tests are presented before the author concludes the outcome of and future work for the project.

II. SYSTEM HARDWARE

In general, the system configuration can be divided into two; i.e. the Monitoring Unit and the Remote Unit. The former is design as portable handheld unit while the latter is designed to be attached to any object. Modular design approach is chosen to develop the architecture of SWiTS to ensure the versatility of the system built. Inadvertently, the modular design permits the system to be easily upgraded, expanded and maintained [2].

The monitoring unit consists of an ATMEGA644 8-bit microcontroller as the heart of the system, a graphical LCD (GLCD) module, a GPS Receiver Module, an RF Module, a Digital compass and a power module. While RF module is used mainly as receiver for data transmission, the GPS and the digital compass modules are used concurrently to identify the current position of the monitoring unit as well as the directional position of a remote unit. Use of graphical LCD module allows for not only the positional but also the directional location of a remote unit to be displayed; thus a more user-friendly human-machine interfacing. Since the serial RX port on the microcontroller is shared between the GPS and the RF receivers a multiplexer is included as part of interfacing circuit. Fig. 1 below illustrates the block diagram of the monitoring unit.

Likewise, the remote unit consists of an ATMEGA324P 8-bit microcontroller as the heart of the system, a 2-line LCD module, a GPS module, an RF transmitter module and a power module. In the remote unit, GPS module provides the positional information which is transmitted to a monitoring unit via RF transmitter module. An additional LCD module is included in the prototype to display the positional information of the remote unit. This information is used as reference to verify the correctness of data transmission as well as the accuracy of directional information on the monitoring unit. Simplified block diagram of a remote unit is shown in Fig. 2.

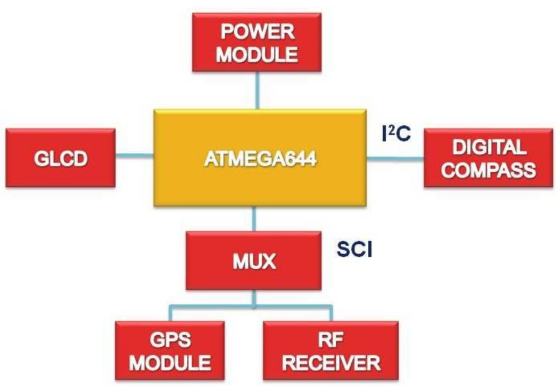

Fig. 1 Simplified Block diagram of monitoring unit

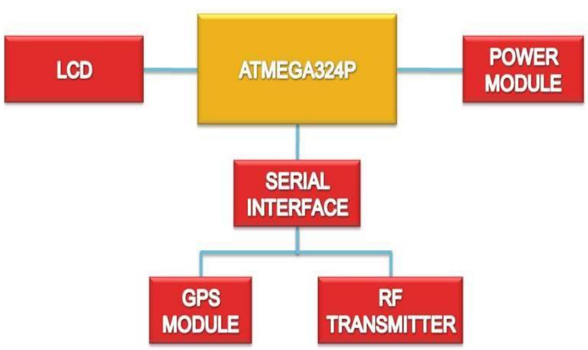

Fig. 2 Simplified Block diagram of a remote unit

The GPS receiver module, SANAV FV-M8, used on monitoring and remote units is a low power consumption model with sensitivity of -158dbm. With 32 parallel channels architecture, this GPS receiver is capable of tracking up to 32 channels of GPS satellites but only 12 satellites can be locked at one time depending on the atmosphere. This results in accuracy of 3.3m [2]. It supports NMEA 0183 data protocol at 4800 bps minimum baud rate. The module interfaces with microcontroller using UART signal level. In the monitoring unit, the GPS receiver is complemented with a digital compass for directional positioning. The Honeywell HMC6352 is preferred in the design as a digital compass. It uses an I2C digital interface slaved to the microcontroller to transfer compass heading data.

There are various license-free technologies, such as the Bluetooth technology, Zigbee technology, infra red technology, RF technology and many more, available for sending information wirelessly. Due to cost, coverage and simplicity, the RF technology is preferred in the design [2]. In this case, a transmitter and a receiver pair are placed on remote and monitoring units respectively. The transmitter uses UHF FM-narrowband that allows the information to be transmitted efficiently in the available RF spectrum. Signal containing information on the latitude and longitude of remote unit will be modulated before it is transmitted in free space using the FSK technique with the carrier frequency of 433MHz. The receiver, on the other hand, demodulates the received signal to its original form. RF transmitter can be used to transmit signal over a distance of 1km radius which is sufficient for the intended application of the tracking system designed [2].

III. System Software

In order to perform effectively as object tracker, the fundamental idea of the system algorithm is to read the information from the GPS receiver on the remote unit and sends it to the monitoring unit. The information received by the monitoring unit is then processed. The aim is simply to compare its position with respect to the remote unit. The information is displayed on screen. Normally the remote unit will periodically update its location by sending its current position or its last known position to the monitoring unit. Two algorithms, one for the master unit and another for the remote unit, are developed, coded in BASIC, compiled and burnt onto the microcontroller for execution.

Fig. 3 shows the simplified flow chart of algorithm developed for the remote unit. Upon system initialization, the program continuously scans the serial buffer register for data received from GPS receiver. Any data packet received is parsed and relevant information such as latitude, latitude sector, longitude and longitude sector is extracted. The extracted information is processed and displayed on the LCD screen. Almost immediately, the same information is processed for serial transmission to a monitoring unit via RF transmission.

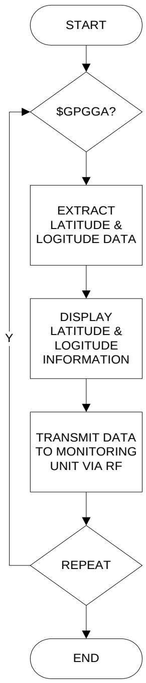

Fig. 3 Flow Chart of Remote Unit Algorithm

On the monitoring unit, once the system is initialized, the program scans the serial buffer register for data availability. Since the serial receiver port is shared between the GPS receiver and the RF receiver, bit-banging technique is used in parsing the information received from signals of different protocols. Data extracted from GPS signal is stored and used as reference location in positional calculation. On the other hand, data extracted from RF signal is analyzed and used in calculating the positional and directional location of remote unit with respect to the monitoring unit. First, the latitude and longitude difference between the monitor and the remote unit is calculated to determine the distance. Then, the direction of the remote unit is calculated with respect to the compass North direction. The calculated positional and directional data of the remote unit is processed and displayed on the GLCD screen. Fig. 4 shows the simplified flow chart of the algorithm developed for the monitoring unit described above.

IV. EXPERIMENTAL RESULTS

Two prototypes, one monitoring unit (Fig. 5) and one remote unit (Fig. 6), are built for design verification. Overall, the SWiTS performed magnificently well. The system is tested thoroughly on its ability to communicate wirelessly in different environment. The communication between the monitoring unit and the remote unit via RF channel functioned properly even in noisy environment. The range of coverage between the two units, however, depended on the performance of the RF transceiver in adverse environment.

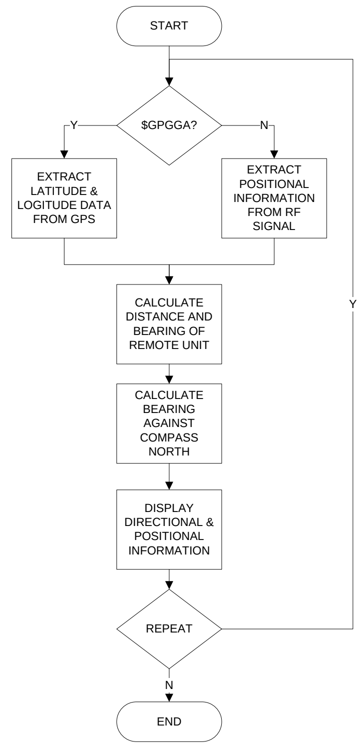

Fig. 4 Flow Chart of Monitoring Unit Algorithm

Fig. 5 Prototype of Monitoring Unit

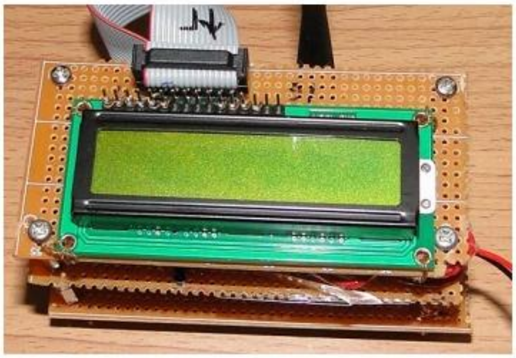

Fig. 6 Prototype of Remote Unit

To demonstrate the tracking ability of SWiTS, the remote unit is carried by a student wandering around in a university campus. The monitoring unit which is placed in a laboratory is able to determine the direction in which the student is moving. The accuracy of the direction and distance are found to be within the acceptable range. It is also observed that SWiTS can function in indoor area [2]. The GPS receiver is capable of detecting up to 10 satellites signal in indoor area. However, it takes up to 6 minutes to lock the satellite signals in indoor environment.

Fig. 7, Fig. 8 and Fig. 9 illustrate some of the example of various results obtained from SWiTS experiments. Fig. 7 shows the current positional reading of remote unit as displayed on the LCD screen. Fig. 8 is a snapshot of GLCD screen showing the latitude and longitude as well as the distance and bearing of the remote unit from the monitor unit. In Fig. 9, direction of the remote unit is shown graphically on the GLCD screen. Throughout the test runs, the results shows that the RF-GPS Tracking system designed is capable of tracking a mobile object as intended.

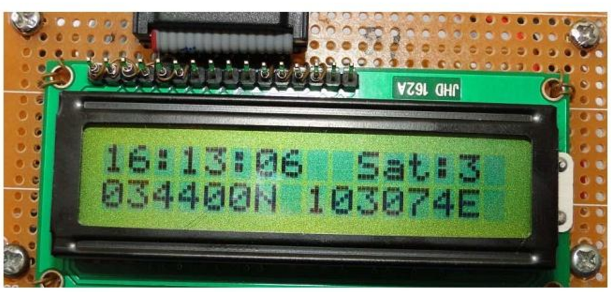

Fig. 7 Screenshot of LCD showing location on Remote Unit

Fig. 8 Screenshot of GLCD showing latitude and longitude coordinates of Remote Unit

Fig. 9 Screenshot of GLCD showing directional position of Remote Unit with respect to North

It is also observed that the portability of the monitoring unit is an advantage when transmission signals are weak. In such cases, the monitoring unit can be moved towards suspected direction until the received signal become acceptably better. Surely, this advantage can be put into good use especially when the SWiTS is used in search-and-track operation.

V. CONCLUSION

In short, it is verified that SWiTS prototype has accomplished its prime task of tracking a mobile object in real time environment. This is done by computing the difference in latitude and longitude between the monitor unit and the remote unit. The current latitude and longitude information of remote unit is transmitted using high performance RF communication channel. The positional and directional location is displayed automatically to indicate the movement of the target object.

Future works proposed includes development of repeater station to extend the coverage where signal is low and, providing full-duplex communication for instant verification data transmission. Some added features can also be easily incorporated as system software/firmware upgrade. These include determination of the distance and object velocity by simply calculate the rate of change of GPS data and embedded emergency alert if the object is moving out of its range.

References

[1] S.T.S. Thong, T.H. Chua and T.A. Rahman, "Intelligent Fleet Management System with Concurrent GPS & GSM Real-Time Positioning Technology," *Proc of 7th Int'l Conf. on ITST*, Sophia Antipolis, 2007, pp 1-6

[2] M.H Abu Talip, "Smart Wireless Tracking System With Qiblat Relocator", BEE Thesis, FKEE, Universiti Malaysia Pahang, Pahang, Malaysia, 2009.